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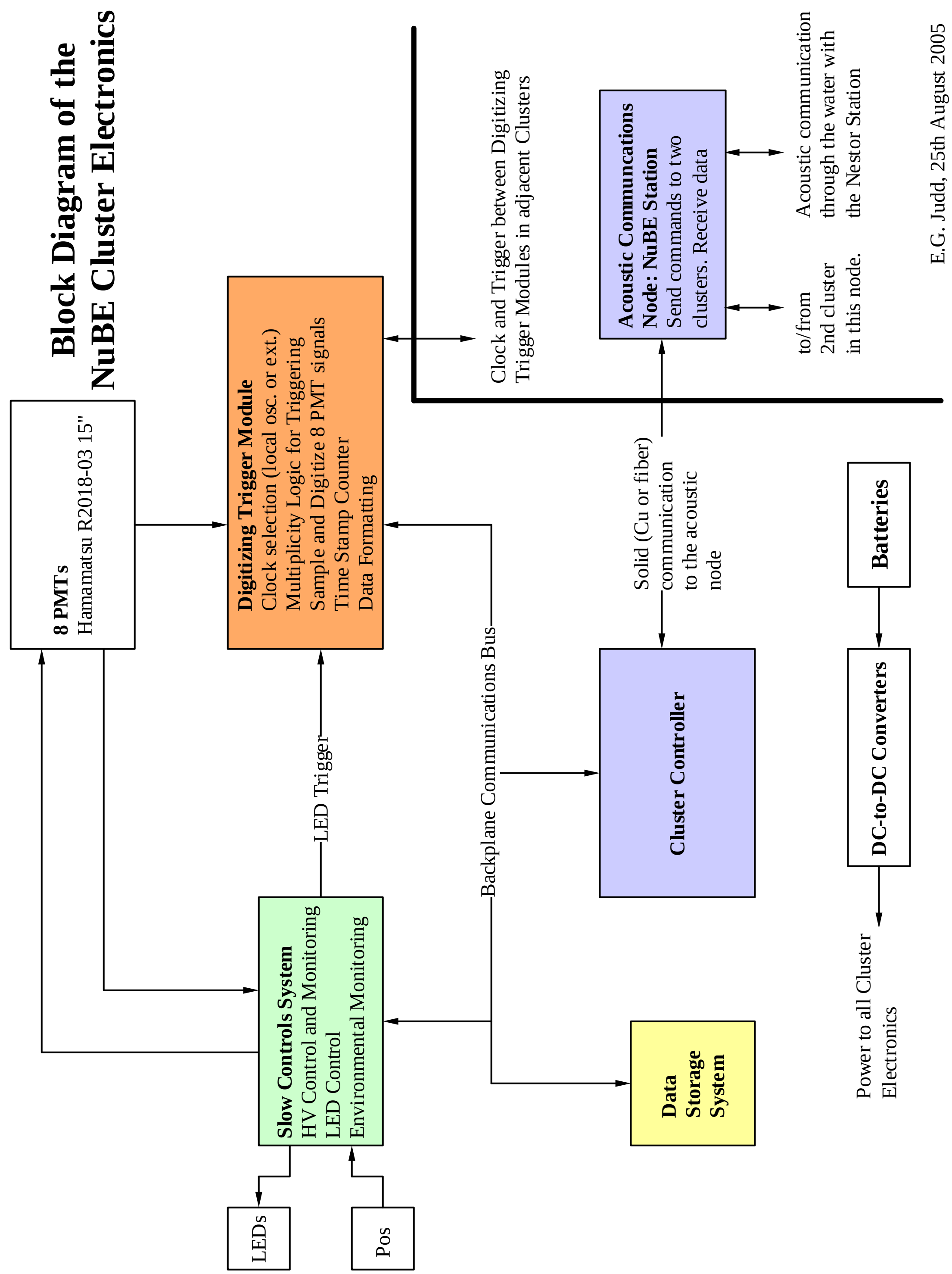
NUBE Sphere Block Diagram



Requirements and Justification for the NUBE Digitizing Trigger Module (DTM)

1. Physical Characteristics

1.1. Form Factor

Requirement: The DTM must conform to an industry-standard form factor that can be plugged into an industry-standard communications backplane along with the Slow Controls System (SCS), the NUBE Cluster Controller (NCC) and the Data Storage System (DSS). The entire assembly must fit inside a commercial deep-ocean-rated pressure vessel.
Justification: Using industry standard form factors and communications backplanes will simplify the development and production of this module. All the NUBE electronics will be housed in a commercially available container.

1.2. Temperature

Requirement: The DTM must be able to operate at temperatures between 14 and 35 degrees Centigrade.
Justification: The ocean temperature at the Nestor/NUBE site is 14 C. During Nestor's March/April tests the temperature inside the sphere leveled out at 29C, and 35C gives us some headroom (see page 25 of http://www.nestor.org.gr/hena_paris/index.html).

1.3. Atmosphere

Requirement: The DTM must operate in a nitrogen atmosphere at atmospheric pressure.
Justification: The pressure vessel will be filled with Nitrogen.

1.4. Power

Requirement: The DTM must consume only a small fraction (currently undefined) of 1W.
Justification: The total power dissipation for those elements of a NUBE cluster that are powered up continuously must be no more than 1W. The elements that are continuously powered are the 8 optical modules, the LED beacon, the NCC and this DTM. NOTE: This must be updated when we know the actual power budget.

2. Connections

2.1. Backplane Communications Bus (BCB)

Requirement: The DTM must connect to the BCB.
Justification: This is the path by which the DTM, SCS and DSS will communicate with the NCC, which is the system responsible for controlling the operation of these modules and reading out their data. The BCB will also provide these modules with their power and ground connections.

2.2. PMT signals

Requirement: The DTM must connect to the signal output of 8 PMTs.
Justification: The purpose of this module is to digitize those signals.

2.3. DTM in Adjacent Cluster

Requirement: The DTM must connect to the DTM of the other cluster in this node via the Trigger Communications Bus (TCB).
Justification: In a NUBE node any hit in one cluster needs to be included in the trigger decision of the other cluster. Also, once either DTM has decided to issue a trigger that decision must be passed to the other to initiate digitization and read-out there too.

2.4. Slow Controls System (SCS)

Requirement: The DTM must connect to the “LED Trigger” output connector of the SCS.
Justification: The SCS needs to use this connection to force the DTM to sample and digitize the PMT signals, with a known, fixed, start time, when an LED event is initiated.

3. Control Functionality

3.1. Local Oscillator

Requirements: The DTM must contain a local oscillator that can be used as the global clock source to control the operation of this module.
Justification: The oscillator will be the default global clock source that the DTM will use unless it is instructed to switch to the external clock. It will also be the backup clock source should that external clock fail.

3.2. External Clock

Requirements: The DTM must also have the ability to accept an externally provided clock via the TCB (from the DTM in the other cluster of this node) and use it as the global clock.
Justification: In order for a pair of DTMs to communicate properly for triggering purposes they need to be operating on the same clock frequency. If one DTM sends its local clock to the other then that condition will be met.

3.3. Master/Slave Selection

Requirements: The NCC must be able to designate this DTM as either the master of the TCB or a slave.
Justification: This will define which DTM should use its local oscillator as the global clock (the master) and which DTM should use the external clock received from the TCB (the slave).

3.4. Master Clock Distribution

Requirement: If this DTM has been designated as the TCB-Master then it must send a copy of its local oscillator clock to the other DTM in this node via the TCB
Justification: This will ensure that both the DTMs in both clusters are using the same frequency global clock, which will make it possible for them to communicate properly for triggering purposes.

3.5. Slave Clock Monitoring

Requirement: If this DTM has been designated as the TCB-Slave then it must monitor the external clock and switch back to the local oscillator if the external clock fails.

Justification: If the external clock fails then this module will stop working unless it is provided with an alternative clock.

3.6. Notification

Requirement: In response to a request from the NCC the DTM must generate a data word that describes the current clock status: “master using local oscillator”, “slave using external clock”, “external clock failed so switched back to local oscillator”, etc….

Justification: The user will need to know which clock is being used.

3.7. Logic Control

Requirement: The DTM must provide the NCC with control of the discriminator threshold on each channel, the Multiplicity Logic Unit (MLU) functionality, the rate at which the scalers are read out and any other aspects of the digitization circuitry that might need to be adjusted.

Justification: The NCC needs to be able to control these aspects of the module’s operation.

3.8. Time Stamp Counter

Requirement: The DTM must count global clock cycles starting from either power-on or an NCC initiated reset. When the MLU issues a trigger the current value of this counter must be included in the data stream. The counter must be large enough that multiple triggers will occur during the time it takes the counter to count from zero up to the maximum value and restart.

Justification: This will enable the user to study the time distribution of events. It will also make it possible to cross-calibrate the relative time between NUBE clusters to an integral number of global clock ticks. This calibration will be performed using data from LED events, when an LED in a known location is fired with a known duration and amplitude. NOTE: The minimum size of the counter will ultimately depend on the slowest trigger rate and the frequency of the global clock.. This section needs to be updated once those numbers are known.

3.9. Event Data Gathering and Formatting

Requirement: Whenever a global trigger is issued the DTM must assemble the data from the 8 PMTs, the time stamp and the full set of trigger information into a formatted event-data package.

Justification: The data needs to be gathered into a known format in order for the user to analyze it.

3.10. Scaler Data Gathering and Formatting

Requirement: Periodically, at a rate set by the NCC, the current values of all scalers and any other relevant information (e.g. the time stamp) must be gathered into a formatted scaler-data package.

Justification: The data needs to be gathered into a known format in order for the user to analyze it.

3.11. Storage

Requirement: The DTM needs enough memory to store multiple events internally before they are read-out by the NCC. A typical event is expected to generate about 1Kbyte of data (8 channels with approximately 400 bits of

digitized data per channel plus 200 additional bits of time stamp and trigger information).
Justification: Data will be read out periodically via the NCC. This module needs to store events until they are read out. NOTE: The bit count is a guess. It needs to be updated when we know the size of the ADCs and shift register. The size of the shift register will depend on the frequency of the global clock and the number of bins we need to record. The clock frequency depends on the time resolution that we need. How many events need to be stored?

3.12. "Busy" Logic

Requirement: The DTM must disable the trigger logic while it is busy processing the last issued trigger, or if there is no more room to store events.
Justification: There is no point in issuing a trigger if it cannot be processed or there is no space to store the data.

3.13. Data Transfer to Controller

Requirement: Data must be sent to the NCC on request.
Justification: The NCC is the system responsible for the large-scale storage of the data.

4. Digitization Circuitry

4.1. Ground and Power Separation

Requirement: The analog and digital power and ground circuits must all be separated from each other. The two ground circuits should meet only at the connection to the BCB ground pin. The two power circuits should meet only at the connection to the BCB power pin.
Justification: This will prevent digital noise being picked up by the analog circuits.

4.2. Termination of PMT signals

Requirement: Each of the 8 channels must be correctly terminated into 50Ω
Justification: If this is not done correctly the PMT signals will be distorted

4.3. Noise

Requirement: The noise generated in the PMT signals by the analog circuitry must be less than 10 mV which is less than 10% of a 120 mV single photoelectron peak (see http://www.nestor.org.gr/hena_paris/index.html on page 36) and is down in the region already dominated by the PMT dark current.
Justification: It must still be possible to distinguish single photoelectron signals from the noise.

4.4. Discrimination of PMT Signals in Trigger Circuit

Requirement: Each of the 8 PMT signals must be input to a discriminator which must be useable down to ¼ of a photoelectron, or 30mV. The discriminator threshold must be adjustable, on a channel-by-channel basis, by the NCC.
Justification: If we discriminate reliably at ¼ of a photoelectron then our ability to detect single photoelectrons approaches 100%. The control is necessary for fine adjustments (if the PMTs are not properly gain-matched

then they will produce single photoelectron pulses of different sizes) and in case we need to raise the discrimination threshold on a noisy PMT.

4.5. <u>Scalers for Discriminator Output</u>

Requirement: A scaler is needed for each of the 8 channels to count the number of hits on that channel. A hit occurs when the PMT signal goes above threshold so the discriminator output changes from 0 to 1. Each scaler should be reset to zero after it has been read out.

Justification: It is necessary to monitor the hit rate on each channel individually in order to monitor their performance.

4.6. <u>Discriminator to Other DTM</u>

Requirement: Whenever any discriminator output is over threshold a signal must be sent to the DTM in the other cluster of this node via the TCB

Justification: The other DTM needs to include any hits from this DTM in its trigger decision.

4.7. <u>Stretching of Discriminator Outputs</u>

Requirement: The 8 local discriminator output pulses, and any discriminator pulse received via the TCB from the other DTM, must be stretched to be up to 60ns long. The actual length must be adjustable by the NCC. One adjustment for all 9 signals is sufficient; there is no need to adjust the length for each channel individually.

Justification: 60ns is the maximum time difference between incoming signals in NUBE. It is set by the time it takes light to traverse the maximum distance across a node, 12.25m, traveling at ¾ of the speed of light in a vacuum (41 ns) plus twice the 8 ns transit time spread of the PMTs (worst case, single p.e.) plus the time it takes the adjacent DTM to send its hit signal to this DTM (~11ns). The minimum stretched pulse length is equal to the period of the global clock. Stretching each discriminator output pulse will make it possible to trigger on coincidences between early and late signals from one muon. NOTE: The 60ns time will need to be adjusted once we know how the DTM-DTM connection will work so we can work out how long it really takes to send a signal from one to the other.

4.8. <u>Multiplicity Logic in Trigger Circuit</u>

Requirement: The 9 stretched discriminator signals must all go to a configurable MLU that will calculate the multiplicity by counting how many of the 9 signals are on. The multiplicity is also known as the "coincidence level". The MLU must then produce a trigger signal whenever the multiplicity exceeds a threshold set by the NCC. It must be possible for the NCC to set up multiple trigger conditions with independent prescales running in parallel. A trigger would be issued whenever any prescale is satisfied.

Justification: This is how the sampling and/or storage of the PMT signals are initiated. The capability of using multiple triggers in parallel is needed in order to make sure rare, important events are triggered while simultaneously continuing to trigger on a subset of very common events.

4.9. <u>Multiplicity Scalers</u>

Requirement: The multiplicity (i.e. the coincidence level) can have one of 10 values between 0 and 9. 10 scalers need to be implemented. Every tick of the global clock the scaler corresponding to the current multiplicity value should be incremented by 1. All 10 scalers should be reset to zero after they have been read out.

Justification: It is necessary to monitor the rate at which each coincidence level is occurring.

4.10. <u>Global Trigger Decision</u>

Requirement: The MLU trigger must be combined with any trigger received from the other DTM via the TCB and any LED trigger from the SCS to create a global trigger that will initiate readout of the digitized inputs.

Justification: This is how the final trigger decision is made in this module.

4.11. <u>Global Trigger to Other DTM</u>

Requirement: The global trigger must be sent to the other DTM via the TCB to force it to readout its digitized data.

Justification: This is how one DTM will force the other to digitize and readout its data.

4.12. <u>Time Resolution of Signal Digitization</u>

Requirement: Once a trigger decision has been made information about the PMT pulses must be digitized and recorded in such a way this module contributes no more than 9.7 ns to the final timing resolution of the leading edge time in NUBE.

Justification: The final timing resolution is defined as $\sigma = \sqrt{\sigma(PMT)^2 + \sigma(el)^2}$ where σ(PMT) is the timing resolution of the PMTs and σ(el) is the timing resolution of this DTM. σ needs to be no more than 10 ns. In NUBE the typical value of σ(PMT) is set by the Transit Time Spread (TTS) of single-photoelectron pulses, which is 5.5ns. A TTS of 5.5ns corresponds to σ(PMT) of 2.34ns, which implies σ(el) must be no more than 9.7ns. NOTE: THIS IS THE CRUCIAL REQUIREMENT. If σ(el) is no more than 9.7ns then we can implement this in a shift register whose bins are twice that size, or 19.4ns, which corresponds to a global clock frequency of 51.5 MHz. The precise value of σ is set by our need to distinguish photons from a Cerenkov cone from photons generated by a bioluminescence event or a potassium-40 decay. This needs to be investigated further and properly justified. Once σ is set then the global clock frequency is set, which then affects the event size and the time stamp counter size.

4.13. <u>Depth of Digitization</u>

Requirement: The total time window must be at least 440ns.

Justification: This is set by twice the maximum separation between the earliest and latest trigger pulses (60ns; see section 3.7) plus 160ns to allow for the late arrival of slow shower particles. If the MLU triggers on the earliest pulse then it will be necessary to digitize and store the 220ns after the trigger. However, if the MLU waits until the latest pulse arrives before issuing a trigger then it will be necessary to digitize and store the 220ns preceding the trigger. A time window of at least 440ns should cover both possibilities.

4.14. Pulse Integration

Requirement: It is necessary to measure the total charge in each PMT pulse. The integrator needs to be able to deal with input pulses ranging in amplitude from zero up to 8V.

Justification: Measuring the total charge will make it possible to reconstruct the number of photoelectrons that originally hit the PMT. From this information it should be possible to reconstruct the energy of the particle that produced the photoelectrons. 8V is where the output of the PMT saturates so no pulse will be larger than that. NOTE: I do not think this is valid for NUBE. I am not sure if we are ever aiming to reconstruct the energy from the pulse heights, or just get the direction. Why do we need the ADC system?

4.15. ADC Gain

Requirements: The analog output of each integration circuit needs to be digitized. The gain does not need to be constant over the full 8V range. A high gain region is needed for pulses up to around 2V. For the larger pulses it would be acceptable if the ADC output saturated.

Justification: A typical single-photoelectron pulse is around 120mV. However, these pulses can be as small as 70mV or as large as 200mV with a tail stretching up to even higher values. A typical double-photoelectron pulse is around 260mV but they can be as small as 200mV or as large as 360mV again with a large high tail (see page 36 of http://www.nestor.org.gr/hena_paris/index.html). NOTE: This needs to be re-written. I am not sure what the actual requirement is, or what the justification is. If we really only need to tell the difference between no photons, one photons or many photons then something very simple will do. See related question about 4.14 above.

4.16. Single-Channel Deadtime

Requirement: Each channel must be dead for no more than 1 μs after each pulse.

Justification: During the Nestor tests in March/April 2003 the maximum single PMT rates seen were bursts of 400 kHz on the upward-looking PMTs. Typical rates on these PMTs were more like 70 kHz (see page 27 of http://www.nestor.org.gr/hena_paris/index.html). The downward-looking PMTs saw typical rates of 50 kHz with bursts up to 80 kHz (see page 28 of http://www.nestor.org.gr/hena_paris/index.html). We will assume that NUBE PMTs will see similar rates. If each channel is dead for 1 μs after its input signal goes over the discriminator threshold then the upward-looking channels will typically be dead for 7% of the time, and the downward-looking channels will typically be dead for 5% of the time. This should be acceptable.

4.17. DTM Deadtime

Requirement: This module must be dead for no more than 10 ms after each trigger issued by the MLU. This includes the time to format the data and store it.

Justification: During the Nestor tests in March/April 2003 the trigger rates were around 3 Hz when the MLU required a 4-fold coincidence and the discriminator thresholds were set to ¼ of a photoelectron (see pages 31 and 39 of http://www.nestor.org.gr/hena_paris/index.html). However, during the commissioning and debugging process triggers that used a lower coincidence level were used, leading to higher trigger rates. We will assume that each NUBE node will encounter similar conditions to the Nestor test. If the module goes dead for 10 ms then the maximum steady state trigger rate than can be achieved is 100Hz which should be big enough.

Requirements and Justification for the NUBE Cluster Controller (NCC)

1. Physical Characteristics

See "Requirements and Justification for the NUBE Digitizing Trigger Module (DTM)", section 1.

2. Connections

2.1. Backplane Communications Bus (BCB)

Requirement: See "Requirements and Justification for the NUBE Digitizing Trigger Module (DTM)", section 2.1.

2.2. Node Acoustic Station (NAS)

Requirement: The NCC must have a connection to the NAS of this NUBE node.
Justification: The NAS will be used to communicate with the outside world, both for control and data read-out.

3. Functionality

3.1. DTM Power On/Off

Requirement: The NCC must be able to turn on power to the DTM when the system is powered on, and turn off power to the DTM if necessary.
Justification: Since NUBE is operating on batteries it is necessary to eliminate non-essential power dissipation to maximize the life of the experiment. If the DSS is full then there is no space to store any more data so there is no need to keep the DTM powered up.

3.2. DTM Configuration

Requirement: On power-up the NCC must configure any control registers and memories in the DTM using a predefined set of configuration data. It must also be possible for the user to change the configuration set and prompt the NCC to reconfigure the DTM via the acoustic link.
Justification: The NCC is responsible for ensuring that the DTM is operating in the correct way. The user needs the ability to change the configuration since data analysis may indicate that the DTM is not optimally configured.

3.3. DTM Read-Out

Requirement: At predefined intervals the NCC must read out all event data stored in the DTM and save it in the DSS. It must be possible for the user to change the read-out interval via the acoustic link.
Justification: The NCC is responsible for ensuring that all the event data is saved locally until it can be read out either via the acoustic link or after the string has been retrieved. The user needs the ability to change the read-out interval since data analysis may indicate that the trigger rate is higher or lower than expected so the read-out rate can be adjusted accordingly.

3.4. SCS Power On/Off

Requirement: At predefined intervals the NCC must turn on power to the SCS, and once data has been gathered the SCS must be powered down. For this purpose the SCS should be considered as multiple separate pieces each of which is powered up or down at a rate appropriate to its function. For example, the PMT power and HV control should be on all the time while the acoustic position monitor only needs to be on when it is time to record the position.

Justification: Since NUBE is operating on batteries it is necessary to eliminate non-essential power dissipation to maximize the life of the experiment. It is not necessary for the whole SCS to be switched on all the time.

3.5. <u>SCS Configuration</u>

Requirement: Whenever any piece of the SCS is powered up the NCC must configure that piece using a predefined set of configuration data. It must also be possible for the user to change the configuration set and prompt the NCC to reconfigure that piece of the SCS via the acoustic link.

Justification: The NCC is responsible for ensuring that the SCS is operating in the correct way. The user needs the ability to change the configuration since data analysis may indicate that the SCS is not optimally configured.

3.6. <u>SCS Read-Out</u>

Requirement: Once any piece of the SCS involved in monitoring has been powered up and configured the NCC must read out all monitor data, form it into a data buffer with the appropriate priority flag (see Section 3.9) and save it in the DSS.

Justification: The NCC is responsible for ensuring that all the SCS monitor data is saved locally until it can be read-out, either via the acoustic link or after the string has been retrieved.

3.7. <u>SCS Data Analysis</u>

Requirement: When monitor data is read out of the SCS the NCC must perform a simple analysis to determine the health of the system being monitored. It must then take the appropriate action if it detects a problem. For example, if the current draw from a PMT rises above some threshold, indicating a leak in a Benthos sphere, then the NCC must shut off all power to that PMT to prevent the batteries being drained. The results of the data analysis, and any action taken, must be saved in the DSS along with the original data.

Justification: Since NUBE will be operating largely autonomously the NCC is responsible for monitoring the basic health of the cluster and responding to a variety of problems. The data must be saved in order for the user to be able to reconstruct the chain of events later.

3.8. <u>DSS Power On/Off</u>

Requirement: The NCC must power on the DSS only during the time when it has data from the DTM or the SCS that needs to be stored. Once the data has been stored the NCC must power down the storage system.

Justification: Since NUBE is operating on batteries it is necessary to eliminate non-essential power dissipation to maximize the life of the experiment. It is not necessary for the DSS to be switched on all the time.

3.9. DSS Status

Requirement: The NCC must monitor the status of the DSS. If it detects that the DSS is full it must power down all other systems; the DTM, the PMT power and HV and all other parts of the SCS. These systems should remain off until after the data has been read from the DSS, at which point all other systems can be powered up and data taking can resume.

Justification: Since NUBE is operating on batteries it is necessary to eliminate non-essential power dissipation to maximize the life of the experiment. It is not necessary for system to be powered up and triggering more events if there is no space to store the data.

3.10. Data Transfer

Requirement: On receipt of a command from the acoustic link the NCC must power on the DSS and transmit all the requested data to the NAS. The user will specify the range of priority flags in the command and the NCC must loop through all events currently in the DSS, check the priority flag of each one and transmit only those with flags in the requested range. After the data transfer is complete the DSS can be powered down.

Justification: This is how the data will be read-out while NUBE is deployed.

3.11. Data Rates

Requirement: What are the requirements on the data rates for the link to the Node Acoustic Station?

Requirements and Justification for the NUBE Slow Controls System (SCS)

1. Physical Characteristics

1.1. Form Factor, Temperature and Atmosphere

See "Requirements and Justification for the NUBE Digitizing Trigger Module (DTM)", sections 1.1, 1.2 and 1.3.

1.2. Power

Requirement: The SCS may consume a large fraction (currently undefined) of 9W.

Justification: In NUBE the SCS will only be powered up occasionally; it is expected to be on for approximately 1% of the time. During that time the peak NUBE power budget is 10W. 1W will be used by those components that are powered up all the time (the 8 optical modules, the LED beacon, the DTM and the NCC) leaving 9W to be split between this SCS and the DSS. NOTE: This section must be updated when we know what the actual power budget will be.

2. Connections

2.1. Backplane Communications Bus (BCB)

Requirement: See "Requirements and Justification for the NUBE Digitizing Trigger Module (DTM)", section 2.1.

2.2. Monitor Inputs

Requirement: The SCS must receive signals from various monitoring devices: PMT HV monitor, acoustic position monitor, power supply voltage, compass, accelerometer, humidity and temperature sensors, etc…. The full list is currently undefined.

Justification: These conditions need to be monitored.

2.3. Power On/Off Switch to PMTs

Requirement: The SCS must connect to the Power on/off switch for each PMT.

Justification: The PMTs need to be switched on in order to function, and off if there is a problem (e.g. if a Benthos sphere leaks and shorts all its electronics).

2.4. PMT HV Control

Requirement: The SCS must connect to the low voltage control input to each PMT.

Justification: This signal is used to control the Cockroft-Walton base and set the required HV

2.5. Power On/Off Switch to Calibration LEDs

Requirement: The SCS must connect to the Power on/off switch of each LED.

Justification: The LEDs must be switched on in order to function, and off if there is a problem (e.g. if the housing leaks and shorts all its electronics).

2.6. "Fire" Command to Calibration LEDs

Requirement: The SCS must connect to the LED control input.

Justification: This is used to actually fire the LEDs.

2.7. <u>“LED Trigger” Link to DTMs</u>

Requirement: The SCS must connect to the DTMs “LED Trigger” input.
Justification: The SCS needs to tell the DTM when it has fired the LEDs.

3. <u>Functionality</u>

3.1. <u>Digitization of Monitor Signals</u>

Requirements: The SCS must provide the ability for the NCC to control the digitization of the analog monitor inputs (e.g. set ADC gate width, initiate digitization, etc…) and read-out the digitized data via the BCB
Justification: Only digitized data can be stored in the DSS, and the monitor data needs to be saved and analyzed along with the PMT data.

3.2. <u>PMT Power Switch Control</u>

Requirement: The SCS must provide the ability for the NCC to switch on and off the power to individual PMTs.
Justification: The NCC needs this basic control over individual PMTs.

3.3. <u>PMT HV Control</u>

Requirement: The SCS must provide the ability for the NCC to set the HV on individual PMTs.
Justification: The NCC needs control over individual PMT’s HV.

3.4. <u>LED Power Switch Control</u>

Requirement: The SCS must provide the ability for the NCC to switch on and off individual LEDs.
Justification: The NCC needs this basic control over which LED’s are available to fire and which are switched off.

3.5. <u>LED Fire Control</u>

Requirement: The SCS must provide the ability for the NCC to set up an automatic sequence of LED firing events specifying the frequency (up to at least 100Hz, the minimum requirements on the DTMs), LED selection, and light intensity of each event. The control circuitry must be stable against small changes in electrical components and must produce very stable, sharp pulses (1-2ns).
Justification: This is necessary to ensure a regular sequence of calibration events interspersed throughout the data. NOTE: What is the required rate?

3.6. <u>“LED Trigger” Command to DTM</u>

Requirement: The SCS must generate a trigger signal for the DTM whenever any LED is fired.
Justification: In order to use the LED system to fully investigate the response characteristics of the system (e.g. effects of light amplitude, cables, differences between PMTs, differences due to different levels of multiplicity logic, etc…) it would be helpful for the LED events to always be triggered on the DTM with a fixed time relationship to the actual LED firing.

Requirements and Justification for the NUBE Data Storage System (DSS)

1. Physical Characteristics

1.1. Form Factor, Temperature and Atmosphere

See "Requirements and Justification for the NUBE Digitizing Trigger Module (DTM)", sections 1.1, 1.2 and 1.3.

1.2. Power

Requirement: The DSS may consume a large fraction (currently undefined) of 9W.
Justification: In NUBE the DSS will only be powered up occasionally; it is expected to be on for approximately 1% of the time. During that time the peak NUBE power budget is 10W. 1W will be used by those components that are powered up all the time (the 8 optical modules, the LED beacon, the DTM and the NCC) leaving 9W to be split between this DSS and the SCS. NOTE: This section must be updated when we know what the actual power budget will be.

2. Connections

2.1. Backplane Communications Bus (BCB)

Requirement: See "Requirements and Justification for the NUBE Digitizing Trigger Module (DTM)", section 2.1.

3. Functionality

3.1. Size

Requirement: How much long-term data storage do we need?
Justification: What's the justification?

3.2. Access Time

Requirement: How fast do we need to be able to read/write from/to the DSS?
Justification: Why?

Implementation of the NUBE DTM

1. Introduction

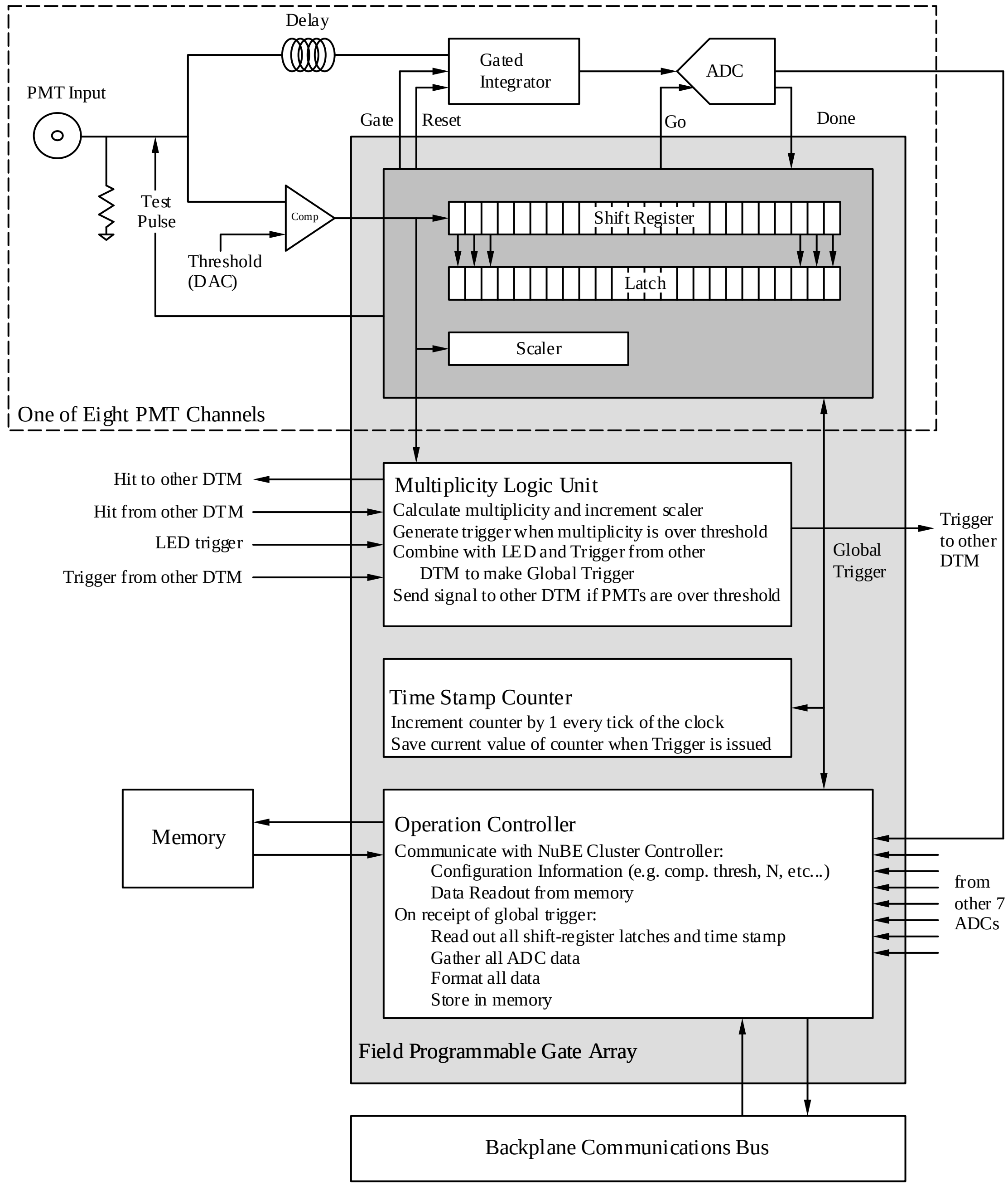


Figure 1: A schematic Diagram of the NUBE DTM

The NUBE DTM is an 8-channel module that uses shift registers, to record the time at which each input pulse crosses a threshold, and gated-integrator ADCs to record the charge in each input pulse. Each DTM is designed to operate as one of a pair that communicates for triggering purposes. The modules will be housed in separate electronics spheres in adjacent clusters. A schematic diagram of the module is shown in Fig. 1. The module consists of 8 identical input channels designed to be driven by a PMT output, a multiplicity logic unit (MLU), a Time Stamp Counter, a memory block and control logic that provides an interface to an external comtroller. All the logic is implemented in a Field Programmable Gate Array (FPGA). The various functional blocks will be described in the following sections of this document.

2. Clock Distribution

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3. Input Channel

3.1. Analog Circuit

3.2. Digital Circuit

3.2.1. Shift Register and Latch

3.2.2. Test Pulse Generator

3.2.3. Control Logic

4. Multiplicity Logic Unit (MLU)

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4.1. Multiplicity Trigger

4.2. Global Trigger

4.3. Busy Logic

5. Time Stamp Counter and Shift Register

6. Memory

7. Operation Control

Glossary

BCB	Backplane Communications Bus
DTM	Digitizing Trigger Module
DSS	Data Storage System
MLU	Multiplicity Logic Unit
NAS	Node Acoustic Station
NCC	NUBE Cluster Controller
NUBE	Neutrino Burster Experiment
PMT	Photomultiplier Tube
SCS	Slow Controls System
TCB	Trigger Communications Bus